Anti-Microbial and Self-Cleaning Properties of Photocatalytic Surface Treatments and their Potential Use for Space-Based Applications

Completed Technology Project (2012 - 2013)

Project Introduction

The purpose of this project was to implement a method to assess self-cleaning properties of commercially available photocatalytic surface treatments for their potential use for both Earth-based and space-based applications.

The NASA Office of Planetary Protection supports studies which examine contamination protection outside of the Earth, including the moon, other planets, planetary vehicles, and the International Space Station (ISS).

This protection is important to preserve the natural states of life outside of Earth, and to avoid contamination that would be detrimental to studies conducted beyond Earth; therefore, a higher level of cleanliness is imposed, more specifically for spacecraft and ISS use. Recent literature suggests the use of photocatalytic titanium dioxide (TiO2) coatings for contaminant control in indoor environments such as residences, office buildings, aircrafts, and spacecraft. However, quantification and validation of these materials for this function is still required.

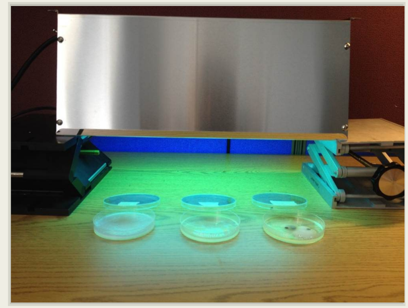
This project looked at a method to evaluate commercially available photocatalytic coating's antimicrobial ability in a laboratory setting to consider their potential use in reducing the transmission of disease in a real life setting. These types of studies provide critical preliminary scientific information that can be used to help validate the utility of these commercially availableTiO2 coatings for antimicrobial purposes.

In practice, cleaning and disinfection of surfaces involves a considerable amount of effort, high consumption of energy and chemical detergents, and consequently high costs.

Current methods to sterilize assembled flight hardware elements include dry heat processing, gamma irradiation and hydrogen peroxide vapor processes. Items such as sensors, battery and valve seals, and optical coatings will generally not survive these processes. Because of these issues, NASA is concerned that planetary protection sterilization requirements may make future missions exceedingly costly. Properly illuminated photocatalytic materials have been shown to kill microbes and decontaminate surfaces.

This project assessed the viability of using commercially available photocatalytic coatings as an alternative method of sterilizing previously non-sterilizable flight hardware.

Hygienic photocatalyst coatings are formulated with light activated TiO2 which assists in the deactivation of bio-contamination sources like bacteria, viruses, and Volatile Organic Compounds (VOC's), as well as tough odors. In recent years, photocatalyst coatings have demonstrated successful reduction of transmittable diseases like Bird Flu and Severe Acute Respiratory Syndrome (SARS) infections in high risk areas. Many hospitals and buildings in Asia and Europe have been photocatalytically coated to increase the surface protection of these properties.



Agar Plates Irradiated Under UV Light Box

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Stennis Space Center (SSC)

Responsible Program:

Center Innovation Fund: SSC CIF

For this project, an experiment for testing the effects of commercially available TiO2 solutions in controlling the growth of bacteria, as an antibacterial activity test, was implemented.

Anticipated Benefits

By helping to understand and solve the multi-disciplinary problem of disease transmission, and by providing possible non-toxic, reliable disinfection methods, this technology can be applied in multiple space-based applications, including but not limited to, maintaining planetary protection to benefit NASA funded missions.

Additionally, from a self-cleaning perspective for facilities, NASA as an agency is vigorously researching options for implementing practical preventive maintenance solutions and treatments that help resolve issues associated with energy efficiency. With more than 500,000 facilities and structures across the US, NASA can be instrumental in leading the Nation in the utilization of energy and cost-efficient designs. As a major consumer, spending over (I don't know what this number is, but we can't possible spend $200 Billion annually, since the fiscal NASA budget is only $19 B) annually in energy related costs, NASA can pioneer the path towards promoting energy efficiency, and reduced energy consumption. By retro-fitting existing exterior structures with photocatalytic coatings, a proactive way to reduce energy consumption can be demonstrated.

Benefits to NASA unfunded missions and planned missions include building the foundation for future rigorous, systematic and scientific evaluations to quantify how illumination and environmental conditions impact the performance of photocatalytic materials. Further development and intelligent use of these materials for various applications, including self-cleaning and planetary protection, require these types of evaluations to better understand both their decontamination effectiveness and limits.

Additionally, high power Light Emitting Diodes (LEDs) can provide UV-A radiation optimally tuned for photocatalysis at a wavelength that is fairly benign for most spacecraft components. Recent advances have increased UV LED power per device by an order of magnitude. Optimizing coatings and atmospheric conditions for this wavelength could, in the future, provide a means to achieve significant endospore reduction in tens of minutes. This novel approach could augment current sterilization methodologies and if proven successful, could provide an alternative method of decontamination and/or partial sterilization.

Benefits to the commercial space industry would be similar to those that would

Project Management

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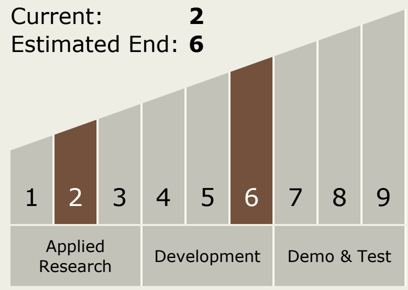
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **6**



Technology Areas

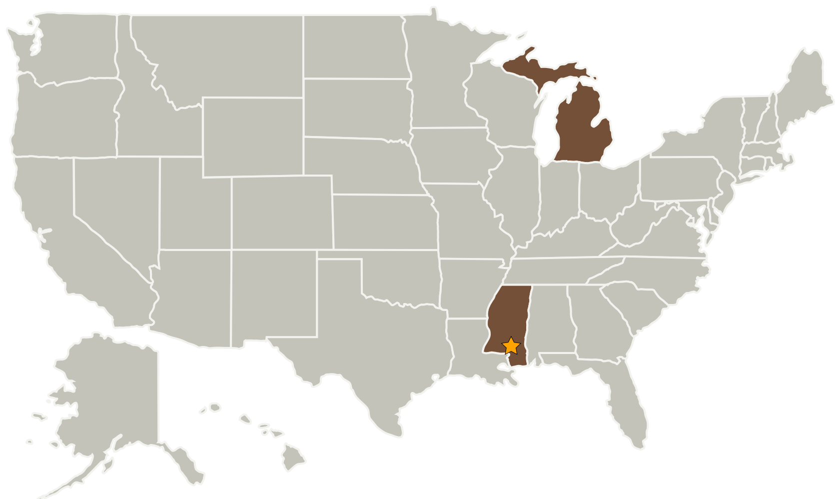
Primary:

- TX07 Exploration Destination Systems
  └ TX07.3 Mission Operations and Safety
    └ TX07.3.5 Planetary Protection

benefit NASA. By providing an alternative means to keep surfaces microbe free, this technology can be applied to multiple space-based applications.

Benefit to other government agencies would be similar to those provided to NASA. By providing a non-toxic novel alternative means to solve the multi-disciplinary problems associated with surface cleanliness and disease transmission, as well as provide a self-cleaning method, this technology could be used by multiple government agencies. These uses could encompass numerous applications, including but not limited to terrorism protection (Army, Navy, DoD), environmental protection (EPA), increased energy efficiency (DoE), and reduced disease transmission (HHS, DHS).

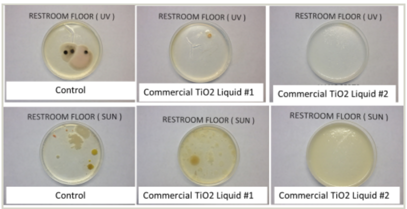
Primary U.S. Work Locations and Key Partners



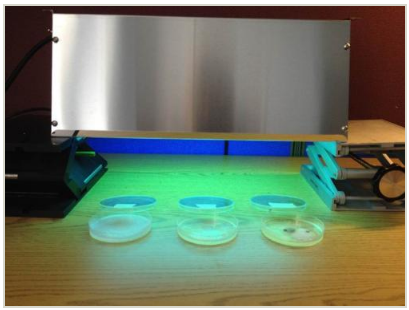
Organizations Performing Work	Role	Type	Location
⭐Stennis Space Center(SSC)	Lead Organization	NASA Center	Stennis Space Center, Mississippi

Primary U.S. Work Locations	
Michigan	Mississippi

Images



Agar Plates
Photographs of Typical Agar Plates Used in Study
(https://techport.nasa.gov/image/3962)



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